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THE TYPE 280 CATHODE-RAY OSCILLOGRAPH

A Precision Oscillograph for the Analysis of Television Signals and Random or Recurrent Transient Phenomena

By R. P. Abbenhouse*

Introduction

Present standards of engineering practice for television broadcasting require a highly precise technique of measurement of the voltage waveforms making up the composite television signal. Specifically, it is of interest to know how well the equipment is handling components such as the leading and trailing edges of the synchronizing pulses. Examination of the synchronizing signal waveform shown in Figure 2 shows that very small time intervals must be measured to greater accuracies than are possible with most oscillographs. For example, it is necessary to measure a time interval of 0.19 microsecond, that is, 0.003 H, where H is the period between the start of two successive lines as shown in item 5 of Figure 2.†

The new Du Mont Type 280 Cathode-ray Oscillograph has been designed primarily for television applications. With this oscillograph it is possible to analyze the operation of video equipment, either studio or remote installation, in terms of the composite television signal. When used in conjunction with a television-station picture monitor, the Type 280 Oscillograph may be employed to display the portion of the

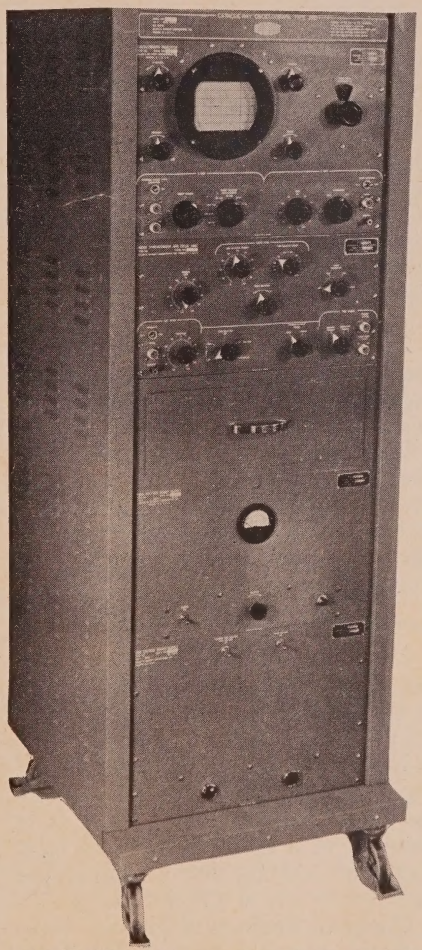


FIGURE 1—The Du Mont Type 280 Cathode-ray Oscillograph.

* Electronic Engineer, Cathode-ray Oscillograph Engineering Section, Allen B. Du Mont Laboratories, Inc.

† In a 525-line, 30-frame per second system, line frequency=15,750 kc, H=63.5 μsec.

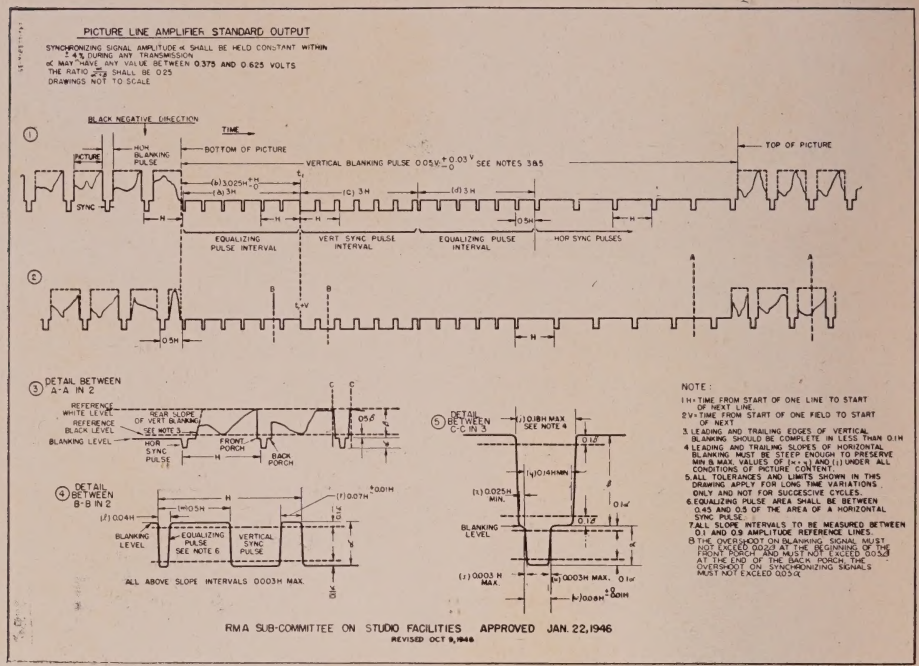

PICTURE LINE AMPLIFIER STANDARD OUTPUT
SYNCHRONIZING SIGNAL AMPLITUDE SHALL BE HELD CONSTANT WITHIN ± 4% DURING ANY TRANSMISSION
MAY HAVE ANY VALUE BETWEEN 0.375 AND 0.625 VOLTS
THE RATIO SHALL BE 0.25
DRAWINGS NOT TO SCALE
BLACK NEGATIVE DIRECTION
TIME
PICTURE
HOR BLANKING PULSE
BOTTOM OF PICTURE
VERTICAL BLANKING PULSE 0.05V SEE NOTES 3&5
TOP OF PICTURE
SYNC
EQUALIZING PULSE INTERVAL
VERT SYNC PULSE INTERVAL
EQUALIZING PULSE INTERVAL
HOR SYNC PULSES
DETAIL BETWEEN A-A IN 2
REFERENCE WHITE LEVEL
REFERENCE BLACK LEVEL
BLANKING LEVEL
REAR SLOPE OF VERT BLANKING
SEE NOTE 3
HOR SYNC PULSE
FRONT PORCH
BACK PORCH
DETAIL BETWEEN B-B IN 2
EQUALIZING PULSE SEE NOTE 6
VERTICAL SYNC PULSE
ALL ABOVE SLOPE INTERVALS 0.003H MAX.
DETAIL BETWEEN C-C IN 3
NOTE:
1 H = TIME FROM START OF ONE LINE TO START OF NEXT LINE.
2 V = TIME FROM START OF ONE FIELD TO START OF NEXT
3. LEADING AND TRAILING EDGES OF VERTICAL BLANKING SHOULD BE COMPLETE IN LESS THAN 0.1H
4 LEADING AND TRAILING SLOPES OF HORIZONTAL BLANKING MUST BE STEEP ENOUGH TO PRESERVE MIN & MAX. VALUES OF (a)-(e) AND (i) UNDER ALL CONDITIONS OF PICTURE CONTENT.
5. ALL TOLERANCES AND LIMITS SHOWN IN THIS DRAWING APPLY FOR LONG TIME VARIATIONS ONLY AND NOT FOR SUCCESIVE CYCLES.
6. EQUALIZING PULSE AREA SHALL BE BETWEEN 0.45 AND 0.5 OF THE AREA OF A HORIZONTAL SYNC PULSE.
7. ALL SLOPE INTERVALS TO BE MEASURED BETWEEN 0.1 AND 0.9 AMPLITUDE REFERENCE LINES.
8. THE OVERSHOOT ON BLANKING SIGNAL MUST NOT EXCEED 0.02 AT THE BEGINNING OF THE FRONT PORCH AND MUST NOT EXCEED 0.05 AT THE END OF THE BACK PORCH. THE OVERSHOOT ON SYNCHRONIZING SIGNALS MUST NOT EXCEED 0.05.
RMA SUB-COMMITTEE ON STUDIO FACILITIES APPROVED JAN. 22, 1946
REVISED OCT 8, 1946

FIGURE 2—Details of the Composite Television Signal.

waveform of the composite television signal that corresponds to any desired portion of the picture.

The Type 280 Oscillograph employs the driven-type sweep circuit which together with a precision delay circuit, wide-band deflection amplifier, high-voltage cathode-ray tube, sweep calibrator, and internal trigger generator with a unique synchronizing system, makes it a useful laboratory instrument for studying random or recurrent transient phenomena.

General Description

The Type 280 Cathode-ray Oscillograph, shown in Figure 1 is made up of an Oscillograph Indicator Unit (Type 305), Video Synchronizer and Delay Unit (Type 306), Low-Voltage Power Supply (Type 307) and a High-Voltage Power Supply (Type 308). It is mounted in a movable enclosed rack fitted with a utility drawer with a sliding cover for use as a desk-top.

The block diagram of Figure 3 indicates the circuit sequence. The Synchronizer in the Type 280 Oscillograph, represented by the blocks below the dotted line in Figure 3, utilizes television-receiver-type clipper and sync-separator circuits. The vertical synchronizing components (c in item 1, Figure 2 are separated out, thus providing a signal of 60 cps recurrence rate. Through the proper application of delay multivibrator circuits and blocking oscillators, and by making use of the difference between the alternate and interlaced field signals (see interval of 6H from t_1, item 1, and 6H from $t_1 + V$, item 2, Figure 2) a sweep driving signal is derived.

The sweep-driving signal occurs at a repetition rate of 30 cps and can be made to correspond to the sync pulse of any particular horizontal line in either field of the television raster by means of suitable panel-mounted controls for these circuits. Since the timing error is only 0.02 microsecond or less in these circuits, any of the components of the composite television signal may be expanded to the limits imposed by the indicator unit of the oscillograph. To cover the interval be-

tween synchronizing pulses, a precision calibrated delay circuit delays the sweep-driving signal over ranges of 100 or 1000 microseconds so that any portion of a synchronizing pulse or any portion of the picture signal may be shown.

The exact occurrence of the indicator sweep with respect to the television picture is indicated by a brightened portion of the monitor picture. This is accomplished by mixing a marker signal, corresponding to the indicator trace, with the composite video that is applied to the picture monitor. Thus, an oscillogram on the Type 280 Oscillograph is identified with respect to the individual horizontal scanning line or group of lines selected by the line- and field-selector controls.

When the composite signal is applied to the Y-axis input terminals of the Type 280 Oscillograph, the marker and composite video signals are mixed as shown in the block diagram, Figure 3, producing two monitor signals, which are available at the terminals marked "VIDEO" and "SYNC." These terminals are located at the rear of the indicator chassis for convenient connection to the monitor.

As seen in the block diagram, the sync-phase inverter and amplifier, i. e., the source of all synchronizing information for the synchronizer unit, receives its signal from the vertical-deflection amplifier in the indicator unit or an external sync-input terminal.

It will be noted that the clipper, sync separator, field- and line-selector circuits may be by-passed and a mode of operation similar to normal oscillograph operation may be obtained. In this case the trigger amplifier-generator circuit may be driven or synchronized by the signal from the sync amplifier. This is accomplished by switching bias and time-constant circuits in the blocking oscillator-type trigger amplifier.

When the circuit operates as a free-running blocking oscillator, it may be synchronized by external or internal signals. It may also serve as a timing source by using a trigger signal available from a front-panel terminal (with or without a delay of approximately 30 microseconds) while also initiating the sweep circuits of the indicator.

The calibrated delay may also be by-passed so that a transient of low amplitude may be used to initiate the sweep with a short starting-time delay. The fixed delay associated with the start of the sweep usually amounts to about 0.25 microsecond or less. The trigger amplifier-generator may be synchronized with signals of frequencies up to 100 kc, although its repetition rate range is 120 to 2500 cps.

For purposes of time calibration, a sweep writing-rate calibrator is provided which applies timing marks to

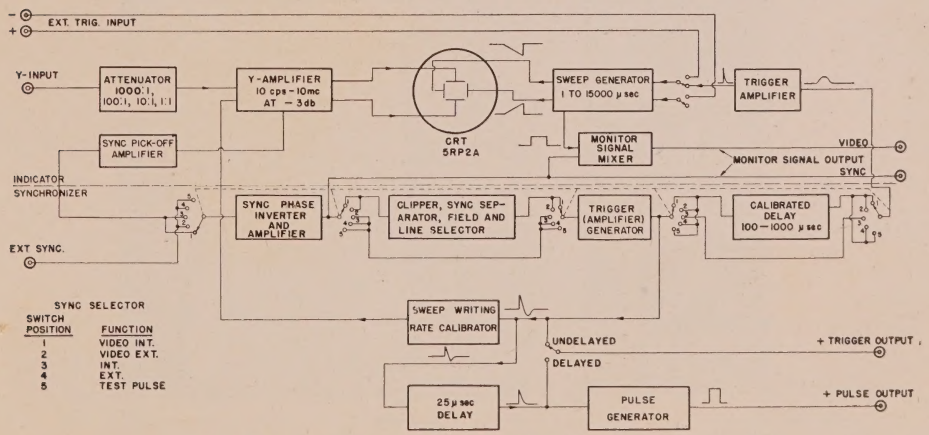


FIGURE 3—Block Diagram of the Type 280 Oscillograph.

the vertical-deflection circuits independently of external signals. This circuit is a gated or keyed Hartley oscillator operating at one of three frequencies selected by a panel control. Thus the oscillator output signal is timed precisely with respect to other circuit functions such as output trigger, calibrated delay, and indicator sweep. The frequencies available are 100 kc, 1 mc, and 5 mc, corresponding to timing intervals of 10, 1, and 0.2 μsec respectively.

In connection with television-amplifier equipment it is often desirable to measure transient response and time delay; a test pulse is available at a front-panel terminal for this purpose. This test pulse has rise and fall times of the order of 0.02 microsecond, and a duration of approximately one microsecond. It is available with variable amplitude up to approximately 20 volts at a low impedance which depends on the fraction of peak amplitude used. A three-foot length of coaxial cable, terminated with 75 ohms including the amplitude control, forms the output terminal for this pulse. This test-pulse circuit, in conjunction with other features of the instrument, is valuable in the calibration of lumped, constant-delay lines, amplifiers, and other networks.

To provide a stable display of short time intervals, two facilities are required; namely, a precisely-timed or driven high-speed sweep circuit and a deflection amplifier capable of reproducing the steep wavefronts of the television signal.

The indicator portion of the block diagram shows a vertical-deflection amplifier input circuit, the amplifier, the cathode-ray tube, and the sweep generator.

The vertical-deflection amplifier input circuit, which includes a compensated, high-impedance attenuator, also utilizes a cathode follower to isolate the input terminal and associated wiring from the first gain stage of the amplifier. Thus, frequency response of the amplifier is not limited by the input circuit. Four push-pull stages complete the amplifier, with phase inversion in the first stage through cathode degeneration. A dual beam-power pentode, Type 829B, is used in the output stage of the deflection amplifier.

With an over-all accelerating potential of 12 kilovolts applied to the cathode-ray tube, at least two inches of deflection with not more than 10% distortion can be obtained with a band width of 10 mc, depending on the variations normally found in the characteristics of both the output stage and the cathode-ray tube. Figure 4 is a typical response curve for the indicator unit of the Type 280 Oscillograph showing that low-frequency response is also

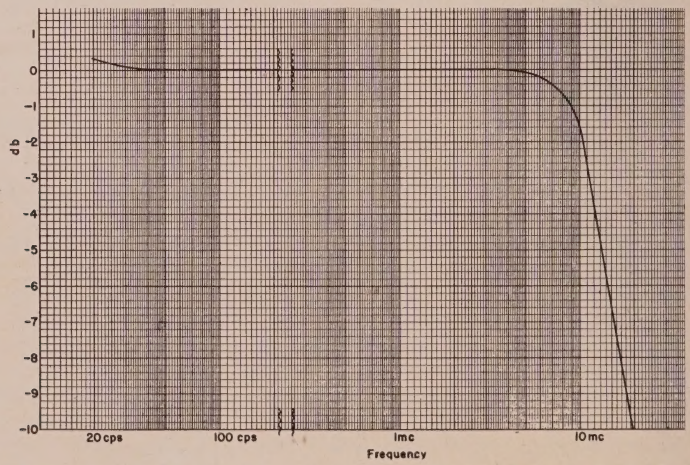


FIGURE 4—Frequency-Response Curve for the Y-Axis Amplifier.

quite satisfactory for most purposes. Over-all sensitivity of the amplifier is 0.1 volt (rms) per inch of deflection. Some increase in sensitivity and maximum deflection is possible by reduction of the final accelerating potential.

Horizontal deflection is obtained by means of a driven sweep circuit providing push-pull deflection that is linear to within 5% for all ranges. Time indication for this type of sawtooth generator is usually specified in terms of sweep duration. Full-scale duration of the sweep is continuously variable from approximately 15,000 microseconds to one microsecond. It is thus possible, with the aid of the writing-rate calibrator and the calibrated delay in the synchronizer, to set the sweep-writing rate to any predetermined value within this range. The sweep is normally initiated by a trigger from the trigger amplifier which is supplied by the synchronizer. Provision has also been made to drive the sweep directly and with minimum delay when the driving signal is of a minimum amplitude of 15 volts or more. A delay of approximately 0.04 microsecond usually occurs when a negative, external trigger is used, while the delay is approximately 0.15 microsecond for a positive external trigger.

The calibrated delay circuit in the synchronizer requires a suitable dial for its control to permit accurate setting of delay. This dial, with an associated ten-turn helical potentiometer, is mounted on the indicator panel to the right of the cathode-ray tube, for greatest convenience in operation. The two delay ranges available are 100 and 1000 microseconds, with the dial reading directly in one-one-thousandth parts of the full-scale range. A minimum delay of 4 and 7 microseconds respectively, in these delay ranges does not affect the accuracy of the dial reading, which is 0.1% or less of full scale for delays beyond the minimum attainable values.

To summarize the above description, the timing diagram of Figure 5 illustrates the sequence of operations that take place in the Type 280 Cathode-ray Oscillograph in presenting a display of some phenomenon as a function of time.

Applications

Some of the uses of the Type 280 Oscillograph have already been indicated in the preceding description. These and others will be further outlined. Consider again the composite television signal shown in Figure 2. By using the facilities of the synchronizer,

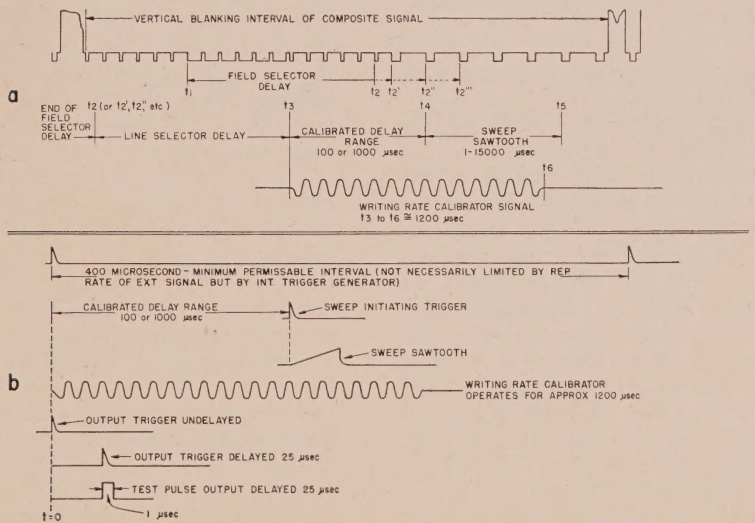

VERTICAL BLANKING INTERVAL OF COMPOSITE SIGNAL
FIELD SELECTOR DELAY
a
END OF FIELD SELECTOR DELAY
LINE SELECTOR DELAY
CALIBRATED DELAY RANGE 100 or 1000 μsec
SWEEP SAWTOOTH 1-15000 μsec
WRITING RATE CALIBRATOR SIGNAL
t3 to t6 ≅ 1200 μsec
400 MICROSECOND - MINIMUM PERMISSABLE INTERVAL (NOT NECESSARILY LIMITED BY REP RATE OF EXT. SIGNAL BUT BY INT. TRIGGER GENERATOR)
CALIBRATED DELAY RANGE 100 or 1000 μsec
SWEEP INITIATING TRIGGER
SWEEP SAWTOOTH
b
WRITING RATE CALIBRATOR OPERATES FOR APPROX 1200 μsec
OUTPUT TRIGGER UNDELAYED
OUTPUT TRIGGER DELAYED 25 μsec
TEST PULSE OUTPUT DELAYED 25 μsec
1 μsec
t=0

FIGURE 5—Timing-Sequence Diagrams for the Type 280 Oscillograph Circuits. (a) for a typical study of television signals. (b) for general-purpose usage.

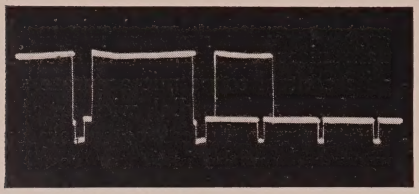


FIGURE 6—Oscillogram of the Vertical-Blanking Signal Showing Two Horizontal Sync and Three Equalizer Pulses. (Approximately 200 μsec sweep at 60 cps repetition rate).

any portion of this signal can be presented on the cathode-ray tube. The horizontal sweep may be triggered at either the frame repetition rate of 30 cps or the field repetition rate of 60 cps by suitable setting of the panel controls. At the 60-cps rate, interlace of two successive fields is clearly shown. For example, it would be possible to display the two vertical-blanking-pulse intervals shown in items 1 and 2 of Figure 2 but superimposed on each other with horizontal pulses of 1 halfway between the horizontal pulses of 2. Then by increasing sweep speed and by suitable adjustments of the synchronizer controls, smaller portions of this oscillogram may be expanded to full scale on the cathode-ray tube. Figures 6 and 7 show the two presentions possible by this process. Figure 6 is the vertical-blanking interval presented at 60 cps, while Figure 7 is the leading edge of some particular horizontal blanking and sync pulse expanded by the above process.

Measurements of the duration of the various parts of the signal may be accurately made, with the aid of the calibrated delay circuit, for intervals of 1 to 100 microseconds, and with the aid of the writing-rate calibrator, for intervals from 0.05 to 5 microseconds. Accuracies to be expected are nominally 0.1% when using the delay circuit and 1% when using the writing-rate calibrator. By exercising a little care in operation, however, the errors can all be reduced to an absolute value of ±0.02 microsecond. This will be found to be well within the accuracies required by present standard practices for television as defined by the FCC.

Since a standard of black negative

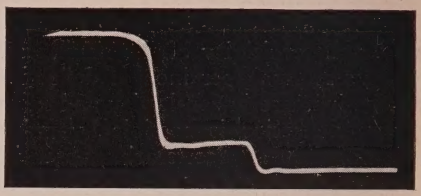


FIGURE 7—Oscillogram of the Leading Edge of a Horizontal-Blanking and Sync Pulse (4 μsec sweep at 30 cps repetition rate).

as shown in Figure 2 has been established for studio facilities as the output of picture transmission-line amplifiers, a positive, peak-clipping circuit is provided in the deflection amplifier. Thus, the negative sync pulses may be expanded in amplitude without the effects of amplifier overloading due to the unwanted blanking and picture components.

There are many other applications for which the Type 280 Oscillograph is well suited. Only a few will be mentioned, but the reader will devise other applications when the specifications for the instrument are fully understood. For example, there are many pulse-type waveforms in use for telemetering, control services, digital counting, communications, etc. They may consist of combinations or individual pulses occurring at regular or random intervals, with characteristics whose precise nature is often very important. Because of the driven sweep used in the indicator and because of the overlapping delay system in the synchronizer, these characteristics may be minutely examined.

The sweep may also be triggered and quickly started by pulses being observed, with only a partial loss of the leading edge of such pulses. The output pulse that is available from the instrument is very useful for checking transient response of amplifier circuits, or amplifier delay by applying it to the input of the amplifier under study and observing amplifier output on the indicator and noting the distortion introduced by the amplifier. As previously mentioned, delay characteristics of cables or lumped-constant delay lines may also be measured with the aid of this pulse.

CHARACTERISTICS

Electrical

Cathode-ray Tube (Type 5RP-A)

Operating Conditions: 7 to 12 kv total accelerating potential with respect to cathode.

Y-axis Amplifier

Input Impedance
Direct—75 ohms or 2.2 meg, 25 $\mu\mu$f.
Probe (Type 261)—5 meg, 10 $\mu\mu$f.

Input Attenuation
Three steps, 100:1, 10:1, 1:1 plus variable of 10:1.
Additional attenuation of 20:1 is added by the Type 261 Probe.

Deflection Factor
Without probe—0.1 volt (rms) per inch of deflection.
With probe—2 volts (rms) per inch of deflection.

Maxmum undistorted deflection at 12 kv total acceleration potential—not less than 2 inches for sine-wave signals or ±1 inch from a-c axis for pulse-type signal.

Sine wave response—down 3 db at 10 mc.

Pulse response—with a 1 μsec pulse rising to 90% of peak amplitude in 0.02 μsec, rise time will not exceed 0.04 μsec between 10% and 90% amplitude.

Maximum permissible signal input—400 volts d-c plus peak a-c.

Miscellaneous—Positive peak-clipping circuit with no attenuation is available on position 1 of step attenuator switch (for additional deflection of negative polarity sync in television composite waveform).

X-axis Deflection

Type of deflection available—driven sweep only.

Sweep Speed—continuously variable from a duration of 1 to 15,000 μsec for 4 inches of sweep length.

Linearity—departure from linearity not more than 5%.

Direction of increasing time—left to right.

Duty cycle—Sweep may be triggered directly at frequencies up to 0.75 times reciprocal of sweep duration in seconds.

Synchronization of X-axis Sweep

Composite Television Sync.
Method—Internal from Y-input or from external sync input at 75 ohms impedance or 0.47 meg and 40 $\mu\mu$f.

Polarity—positive or negative.

Features.
Field and line selector permits selection of any line in either or both interlaced fields to start sweep. Sweep is synchronized to within ±0.02 μsec of the selected line sync pulse.
Repetition rate set at frame or field rate by field selector.
Calibrated delay (see below) delays sweep start with respect to a particular line sync pulse selected by line selector.

Sensitivity.
Internal (from Y-input)—three-fourths-inch deflection provides sufficient sync signal.
External—1 volt peak-to-peak required.

General-Purpose (Internally) through Y-amplifier and Internal Trigger Generator

Repetition rate of trigger—120 to 2500 cps or driven by Y-input signal.

Repetition rate of external signal to which internal trigger generator can be synchronized—120 cps to 100 kc.

Sweep delay—approximately 0.2 μsec.

Sensitivity—±0.25 in. deflection (minimum).

General-Purpose (Externally) with Delayed Sweep and through Internal Trigger Generator

Repetition rate of trigger—120 to 2500 cps or driven by external signal.

Repetition rate of external signal to which internal trigger generator may be synchronized—120 cps to 100 kc.

Sweep delay (through calibrated delay)—4 to 100 μsec or 7 to 1000 μsec, (see below).

Sensitivity—±0.5 volt (peak).

Direct, Driven Sweep

External signal required—pulse-type wave form, positive or negative polarity increasing to 90% of full amplitude in 1 μsec, or less, and 15 volts or more in amplitude and having a duration of 1 μsec or more at 50% amplitude.

Sweep delay.
From positive trigger—0.1 μsec.
From negative trigger—0.04 μsec.
(Time measured between 10% amplitude points of trigger and fast-sweep sawtooth).

Calibrated Sweep Delay

Ranges—100 μsec and 1000 μsec.
Minimum Delay—4 μsec or less on 100 μsec range.
7 μsec or less on 1000 μsec range.

Accuracy—±0.1% of full-scale on either range beyond minimum delay.

Time indication—direct-reading dial.

Sweep Calibration

Method—sinusoidal, vertical-deflection (approx. 1 inch).

Time intervals available—0.2, 1, 10 μsec.

Accuracy—±1%.

Duration of calibrating signal—approx. 1200 μsec.

Start of calibrating signal—coincident with start of calibrated sweep delay.

Output Trigger

Polarity—positive only.

Source—internal trigger generator.

Delay—zero or approximately 25 μsec with respect to start of calibrated delay.

Amplitude—approximately 50 volts.

Rise time—10 to 90% of peak amplitude—0.5 μsec or less.

Output impedance—200 ohms or less.

Output Test Pulse

Polarity—positive only.

Duration—1 μsec ±10%.

Rise and fall time between 10 and 90% of peak—not more than 0.02 μsec.

Amplitude—variable from 0 to 20 volts.

Output impedance—pulse is available at end of a 3-foot coaxial cable terminated with 75 ohms.

Delay—approximately 25 μsec with respect to start of calibrated delay.

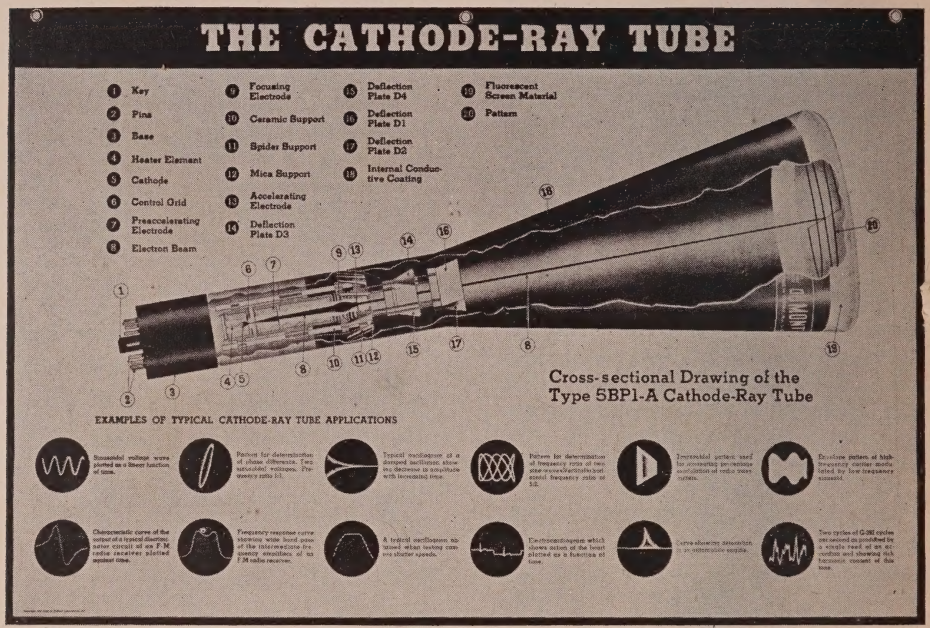
Power Requirements

Power input—690 watts, 115 volts, 50-60 cps.
Operates over ±10% line-voltage variation.
Fuse Protection—in primaries of all power and filament circuits.
Safety Interlocks—power cut off when back or sides are removed.
Miscellaneous—cabinet mounted on brake-equipped swivel casters for mobility.
Line-voltage Outlet—115 volts, 50-60 cps, 230 watts maximum power available on main power supply through main power switch.

MECHANICAL

Panels—smooth, gray-enamel, with white letters and numerals.
Cabinet—accommodates standard relay-rack panels.
Finish—gray wrinkle.
Dimensions—60 in. high, 20¾ in. wide, 22 in. deep.
Top, back, and side panels removable.
Interconnecting cables—sufficient length to allow operation of each unit outside of cabinet.
Weight—287 lbs.

Catalog No.	*Type*	*Description*	*Code Word*
1274	280	115 V. 50-60 cycles with 5RP1A cathode-ray tube	YALCZ
1275	280	Same as above, with 5RP2A cathode-ray tube	YALDA
1276	280	Same as above, with 5RP5A cathode-ray tube	YALDB
1277	280	Same as above, with 5RP7A cathode-ray tube	YALDC
1278	280	Same as above, with 5RP11A cathode-ray tube	YALDD



CATHODE-RAY TUBE WALL CHART

The above photograph is a reproduction of a new wall chart describing the construction and some of the uses of the cathode-ray tube. This chart has been prepared as an aid in classrooms and lecture halls to describe the construction and theory of operation of the cathode-ray tube.

A cut-away section of a Type 5BP1A cathode-ray tube in the upper half of the chart clearly shows the location of the various electrodes and the effect of each on the shape of the electron beam. Each element of the tube is designated with a number for identification purposes. The lower section of the chart shows twelve typical oscillograms as examples of typical cathode-ray tube applications.

This wall chart measures twenty-three by thirty-four inches, and is fitted with three brass eyelets along its top edge for hanging. Copies may be obtained free of charge by addressing requests on school or company stationery to the Technical Publications Section, Allen B. Du Mont Laboratories, Inc., 1000 Main Avenue, Clifton, N. J.